

USE OF AGRICULTURAL PRODUCTION STATISTICS

for

ESTIMATING ULTIMATE ELECTRICAL USAGE

IN RURAL AREAS

By Daniel W. Teare

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Rural electric line design and construction of the past ten years has been done largely without benefit of agricultural engineering assistance. This has been partially due to the fact that the immediate problems of power transmission are major electrical engineering problems in which few agricultural engineers are proficient. Partly because of line designers' lack of training in agricultural power uses, many distribution systems designed and constructed during that period are now proving to be of inadequate capacity to supply the farm power demands of the immediate future. Coming developments will surely place farm power consumption well above and beyond most, if not all of the existing substation capacities. In some areas it is possible that line loads will be greater than installed conductor capacity at peak hours.

In too many cases past estimates of farm power consumption, which partially determine line design, have taken only the farm home into adequate consideration. Where the farm application load was considered, the estimates were seldom, if ever, made by agricultural engineers. It is now evident that design engineers of ten years ago had little, if any, sound information on the possibilities of farm power development. Since agricultural engineers deal with farm power problems of all kind, it seems reasonable that they should be capable of making an outstanding and badly needed contribution to the planning of line design by making comprehensive and accurate estimates of rural power consumption.

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It has been frequently predicted by agricultural engineers and others that revolutionary changes would occur in agricultural production when electricity became widely available. To date such changes have not been apparent in the established production on individual farms, nor in the type of agriculture pursued in the various major agricultural areas. But it has been increasingly apparent that farmers will increasingly employ electricity to enable them to save labor and to improve both the quantity and quality of their long established production, and in other economic applications. There is little evidence that electricity is recognized by farmers as anything but a supplementary source of farm power to be used where most convenient or economic.

Educational Activities Reveal Trends

In conducting educational activities, we have observed that farm people are quick to accept the advantages of electricity when suggested applications relate to their immediate farm and home needs. An example is the widespread acceptance of night lighting in laying houses for increased fall and winter egg production.

With this fact apparent, it appeared reasonable that the basic agricultural production records of a county or state would reveal the kind of electrical farm applications most suitable for educational presentation or sales promotion in a given area.

The desired statistical information was found in the U. S. Census reports. When assembled to show the types of production to which electricity could be easily applied, it proved very helpful in organizing educational demonstration programs.

On several occasions it has been necessary for agricultural engineers to do electrical education work in areas where they had only limited, if any

practical farm experience. Backed with the knowledge gained from a study of basic data, these men were able to do a creditable job in professionally strange territory. For illustration, an engineer going to North Dakota discovered that the state stood sixth in butter-fat production, fourth in hay, and also had a comparatively large poultry production. This was somewhat startling to discover in a state primarily noted for spring wheat and open range. Arriving in the area, it was noticed that a 5¢ premium was being paid for sweet cream as compared with sour. With this combination of facts, the engineer was able to present a farm electrification program of wider application, and which was of immediate interest to both agricultural leaders and the farmers. Among other uses, electric refrigeration was presented on the basis that keeping cream sweet would bring enough additional income to partially or completely liquidate the cost of a large kitchen refrigerator. Other applications included electrification of the cream separator, night lighting and water warming for laying hens, and the electric brooder. Without the information obtained by a study of basic agricultural statistics, it is doubtful that an outstanding practical farm electrification program could have been immediately presented.

In a similar study of a winter wheat farming area in western Kansas, it was found that 35 percent of the farmers kept laying hens and 80 percent reported dairy cows. The average farmer milking cows had sold 500 pounds of butter fat yearly and ^{65 percent} churned 96 pounds of butter for home consumption. In addition, 65 percent of the farmers in the area butchered an average of three hogs each, while less than 2 percent butchered their beef. These figures indicate very good diversification for security against drought and crop failure in an area generally considered as a one-crop farming district. The most significant fact uncovered by the study was that the secondary diversified production offered the greatest economic opportunity to utilize electric power.

In fact, it was estimated that such uses would be approximately ten percent greater than household consumption of power.

Estimates of Ultimate Usage and Power Consumption

The studies made for the purpose of conducting educational programs indicated that similar information could be used to advantage in determining the probable course of electrical farm applications in the future. They could also be used in accurately predicting power consumption for system design to serve unelectrified areas.

Information in Table I was set up as the criteria for determining the future acceptance and ultimate consumption of electric power. Items 1 to 10 give an overall picture of the area under consideration. Some items listed may seem to be intangible at first thought, but careful study of the information will indicate much of the general character of the farm area under consideration. The figures given in Table I apply to a four-county area in western Kansas. Comparison of investments in lands and buildings with the value of implements and machinery will clearly show the tendency to mechanize and the general attitude of the community toward power farming, whether by internal combustion engine or by electric power. In fact, a close correlation has been observed between the degree of mechanization and the degree of electrification on energized projects. Farmers who do their field work with efficient machinery are quite apparently more inclined to apply power to their farmyard production than those whose work is less completely mechanized.

Interpreting Data

In order to use the material in Table I effectively, it was necessary to set up Table II, which establishes the units of production by which total power

TABLE I

FOUR COUNTIES IN WESTERN KANSAS
Census of Agriculture -- 1940

1	Percent Urban Population.....	30%
2	Number of Farms in Area.....	5,265
3	Average Size in Acres.....	377
4	Value of Land & Buildings Per Farm Reporting...	\$16,376
5	Value of Implements & Machinery per Farm Reporting.....	\$13,400
6	Tractors per Farm Reporting.....	1.4
7	Trucks per Farm Reporting.....	1.1
8	Automobiles per Farm Reporting.....	1.2
9	Electric Lines within 1/2 mile of farm home (1,101).....	21%
10	Farms Served by High Line (685).....	13%
11	<u>POULTRY PRODUCTION</u>	
	Percent Farms Reporting Poultry Products.....	85%
	(a) Total Chickens Reported.....	352,982
	(b) Average number of chickens per Farm.....	80
	(c) Dozens Eggs Produced.....	2,687,824
	(d) Dozens Eggs Produced per Farm.....	620
	(e) Dozens Eggs that chickens should have pro- duced.....	1,300
	(f) Percent Hen Efficiency, (Estimated).....	47%
12	<u>DAIRY PRODUCTION</u>	
	Percent Farms Reporting Dairy Cows.....	80%
	(a) Total Dairy Cows.....	22,267
	(b) Dairy Cows per Farm.....	5.3
	(c) Milk Produced (Gallons).....	3,820,171
	(d) Milk produced per Farm (Gallons).....	2,100
	(e) Milk Produced per Farm per Day (Gallons).....	5 $\frac{1}{2}$
	(f) Butter Churned on Farm per Year (Pounds)...	96
	(g) Percent of Farms that Churn.....	65%
	(Note: Only 2 percent sell butter)	
	(h) Butter fat sold -- total pounds.....	1,618,824
	(i) Butter fat sold per farm (pounds).....	500
	(j) Percent Farms Selling Butter Fat.....	82%
13	<u>HOG & BEEF PRODUCTION</u>	
	(a) Percent of Farms Reporting Hogs.....	67%
	(b) Hogs per Farm.....	3
	(c) Percent of Farms Reporting Beef Cattle.....	28%
	(d) Beef Cattle per Farm Reporting.....	10
14	<u>ANIMALS SLAUGHTERED</u>	
	(a) Percent of Farms Reporting Cattle & calves slaughtered.....	1.8%
	(b) Cattle and Calves slaughtered per farm.....	1.8
	(c) Percent Farms Reporting Hogs & Pigs Slaughtered.....	67%
	(d) Hogs & Pigs Slaughtered per Farm.....	3
	(e) Percent Farms Reporting Sheep & Lambs Slaughtered.....	1.1
	(f) Sheep and Lambs slaughtered per Farm.....	3

Table I - Continued

15	<u>VEGETABLE PRODUCTION*</u>		
	(a) Percent Farms Reporting.....		25%
	(b) Value Per Farm.....		\$17.50
	*Excluding Irish and Sweet Potatoes		
16	<u>HAY</u>		
	(a) Farms Reporting Alfalfa.....		9 $\frac{1}{2}$ %
	(b) Acres per Farm Reporting.....		15
	(c) Tons per Farm Reporting.....		23
	(d) Percent Farms Reporting Sorghum Hay.....		58%
	(e) Acres per Farm Reporting.....		16
	(f) Tons per Farm Reporting.....		24
	(g) Percent Farms Reporting All Hay (Except Sorghum).....		22%
	(h) Acres per Farm Reporting.....		19
	(Tonnage of "All Hay" not shown)		
17	<u>SILAGE</u>		
	(a) Percent Farms Reporting Corn Silage.....		22%
	(b) Tons per Farm Reporting.....		56
	(c) Percent Farms Reporting Sorghum Silage.....		7%
	(d) Tons per Farm Reporting.....		124
	(e) Average tons all silage per Farm Reporting.....		72
*18	<u>IRRIGATION INFORMATION</u>		
	(a) No. of farms Reporting.....		284
	(b) Average size in Acres.....		82
	(c) Wells Pumped.....		236
	(d) Gal. per min. yield (Av. per Well).....		800
	(e) No. Pumping Plants.....		336
	(f) H.P. of Prime Movers - total.....		
	(g) Pump capacity - G P M.....		
	(h) Pump lift from Pumped Wells.....		39
	(i) No. of idle installations in 1940.....		100
	(j) Percent of Stations not Used in 1940.....		30%

*Note: Two counties added on Item 18 to show extent of irrigation in the immediate vicinity of the four counties which were the subject of this study.

<u>GRAIN CROP PRODUCTION</u>			
Kind of Grain	Bushels	Acres	Percent Farms Reporting
Wheat	6,155,734	632,195	79%
Oats	27,095	3,188	5%
Corn	268,554	30,527	11 $\frac{1}{2}$ %
Sorghum	184,445	14,668	13%
Barley	97,099	13,160	12%
Total	6,728,927	693,738	

TABLE II

SUGGESTED PRODUCTION UNITS

for 10,000

ELECTRICAL APPLICATION STUDY

I - Livestock and Livestock Products

A. Poultry

- (a) 100 laying hens
- (b) 300 chicks
- (c) 600 dozen eggs
- (d) 150 broilers (for farm production)

B. Dairy Animals and Products

- (a) 5 milk cows
- (b) 15,000 pounds of milk
- (c) 500 pounds butter fat
- (d) 100 pounds butter fat (home churned)

C. Hogs and Beef

- (a) 1 brood sow
- (b) 3 butcher hogs (home cured meat)
- (c) 5 steers or herd animals
- (d) 1 butcher beef (home meat supply)

II - Field Crops, Grains, Fruit and Vegetables

A. Hay Crops

- (1) Legumes - 50 tons
- (2) Tame Hay - 50 tons
- (3) Wild Hay - 50 tons
- (4) Sorghum Hay-50 tons

B. Grain Crops

- (1) 1000 bushels small grain and corn.

C. Silage Crops

- (1) 10 acres Corn or Sorghum
- (2) 15 acres Legumes
- (3) 10 acres Sorghum
- (4) 50 tons Ensilage

III - Power Applications

- A. Feed Grinding - 5000 pounds
- B. Irrigation - 50 acre-feet, or 1 foot per acre per year.

usage of the various applications is determined. These units may be established for an agricultural region, a type of farming, or for a restricted area if desired. There are several methods of determining the size of the various units. One method is to use the capacity of the electrical equipment generally available. For illustration, 300-chick size brooders are commonly used and readily fitted to the type of poultry production in the area. Another method is to choose the same units as those commonly used in experiment station reports and bulletins. In poultry production, much of the material presented is based on 100-hen flocks. Although the average for this area was only 80 hens per farm, it was within reason to use 100 hens as a unit.

It is generally necessary to raise 300 unsexed chicks to insure enough pullets for rigid culling to obtain a good 100-hen laying flock. Consequently, the chick and hen units are proportionate. Since half of unsexed chicks are cockerels, 150 broilers were taken as a unit. Another method in selecting units size was to use average production or yearly farm sales as a guide. It will be seen in Table I that the average sale of butter fat per farm in this area was 500 pounds and milk 16,800 pounds annually. Since 15,000 pounds of $3\frac{1}{2}$ percent milk would yield approximately 500 pounds of butter fat, these two values were chosen for whole milk and butter fat units. After determining unit size, it is only necessary to establish an average electrical consumption for the unit in order to obtain the annual kwh consumption in the commodity production of the area. To clarify the simple mathematical process used, the following formulae were set up:

FORMULA I

$$(N \times X) K_1 = K_2$$

N = Connected Farms

Where: X = The estimated percentage of users of an appliance at maturity of the power utilization program.

X is empirical.

K₁ = The annual KWH consumption of any application as determined by metering or experimental records.

K₂ = The total line consumption of power with the appliance when estimated saturation is obtained.

The above equation is a simple formula used with household appliances or farm equipment when the consumption of power is not widely influenced by the number of people benefiting or the production units involved.

Example: The radio, refrigerator, house lighting, yard lighting, washing machine, etc.

FORMULA II

$$(N \times X) \left(\frac{Q \times K_1}{U} \right) = K_2$$

N = Connected Farms
Where: X = The estimated percentage of users of an electrical application or type of equipment at maturity of the power utilization program. Again X is empirical.

Q = The average user production of a commodity as shown by the basic production statistics in Table I.

U = The production unit of a commodity as determined in Table II

K₁ = The average annual KWH consumption of the production unit as determined in Table II

K₂ = Same as in Formula I.

Using the formula with the values of Q , U , and K_1 as shown in Tables I and II, the material shown in Table III was calculated.

Table III contains the information that answers the sixty-four dollar question "What will farm power consumption be twenty-five years after line construction?" The estimate for this area indicates that an average of 465 kwh per month will be used.

In an effort to check this estimated power consumption for accuracy, a comparison with actual consumption on a line in a similar farm area in another section of the United States was made. This check area had larger farms than those in Kansas, but other phases of the farm program, including crops grown and machinery owned and used, were comparable. It was found that 283 farm users were averaging 459 kwh monthly, and that project was only ten years old. The significant fact is that present power utilization on the check area is 50 percent greater than the most optimistic estimate made before the line was built.

TABLE III

ESTIMATED FARM POWER UTILIZATION

Four Western Kansas Counties

Area Farm Population - - - - -		5,265		
Total Farms Connected - - - - -		2,085 = N		
	X Factor	N x X	K ₁	K ₂
	% User Acceptance	No. Farmer Acceptance	Annual KWH Ea.	Total Ann. KWH
<u>APPLIANCE</u>				
<u>POULTRY PRODUCTION</u>				
1 Night Lighting	75%	1564	35	43,790
2 *Brooders (300 chick size)	65%	1355	300	406,500
3 Water Warmer	50%	1042	100	83,360
<u>DAIRY PRODUCTION</u>				
4 *Cream Separator	65%	1355	15	20,275
5 *Home Pasteurizer	60%	1251	365	456,615
6 Churn	60%	1251	5	6,005
7 *Milking Machine (Portable Unit)	50%	1042	120	125,040
8 *Dairy Water Heater	20%	417	400	166,800
9 *Stock Water Heater	20%	417	300	125,100
10 *Milk Cooler	2%	42	900	37,800
<u>HOME MEAT AND FOOD PRODUCTION</u>				
11 *Food Choppers	90%	1877	5	9,335
12 *Freezer Chests	50%	1042	1200	1,250,400
13 *Garden Watering	50%	1042	250	260,500
14 *Pig Brooder	20%	417	25	10,425
<u>ROUGHAGE CROPS</u>				
15 Irrigation Pumps	10%	208	5500	1,876,160
16 Ensilage Cutters	5%	104	50	7,488
17 Hay Driers	3%	62	2500	71,300
18 Ensilage Blowers	2%	42	50	2,100
<u>FARM SHOP</u>				
19 *Electric Grinder (Emery Wheel)	90%	1877	60	112,620
20 *Air Compressor	50%	1042	35	36,470
21 *Electric Drill (Portable)	40%	834	15	12,510
22 *Electric Welder	25%	521	200	104,200
23 *Battery Charger	25%	521	25	13,025
24 *Drill Press	20%	417	12	5,004
25 *Wood Saw	10%	208	12	2,496
26 *Paint Spray	10%	208	3	624
<u>MISCELLANEOUS</u>				
27 *Farmstead Lighting (Outside House)	100%	2085	120	250,200
28 *Automatic Water Pressure System	90%	1877	250	469,250
29 *Seed Cleaner	50%	1042	5	5,210
30 Grain Elevator	40%	834	10	12,510
31 Feed Grinder	25%	521	100	104,200
32 *Electric Fence	25%	521	85	44,285
33 *Seed Treater	25%	521	5	2,605
34 Corn Sheller	10%	208	10	2,080
35 *Barn Ventilating	5%	105	50	5,250
36 *Lamb Brooder	5%	105	5	525
37 Feed Mixer	10%	208	25	5,120

(*Indicates Use of Formula I in the Solution.)

Total KWH

6,147,227

TABLE III

Estimated Farm Household Usage*

APPLIANCE	X Factor	(N x X)	K	K ₂
	% User Acceptance	No. Farmer Acceptance	Annual KWH Ea.	Total Ann. KWH
1 House Lighting	100%	2085	360	750,600
2 Radio	100%	2085	100	208,500
3 Small Miscellaneous Appliances	100%	2085	60	125,100
4 Electric Iron	95%	1981	60	118,860
5 Refrigerator	90%	1877	420	788,340
6 Washing Machine	90%	1877	35	65,695
7 Electric Fans	90%	1877	10	18,770
8 Electric Range	50%	1042	1440	1,500,480
9 Hot Plate	40%	834	300	250,200
10 Water Heater	25%	521	3000	1,563,000
11 Ironer	20%	417	120	50,040
12 Roaster	15%	313	300	93,900
13 Furnace or Blower	15%	313	100	31,300
Total KWH				5,564,785

*All Household Appliances were
calculated by formula I

TABLE I(A)

- 1 - Population of Area - Rural and Urban
- 2 - Number of Farms in area
- 3 - Average Size in Acres
- 4 - Lands and Buildings Valuation - Average Per Farm
- 5 - Value of Implements and Machinery
- 6 - Small grains - percent of farms reporting acreage, & bushels

(a) Corn	(b) Wheat	(c) Oats
(d) Sorghum	(e) Barley	(f) Rye
- 7 - Hay - Percent of Farms Reporting:

(a) Alfalfa - Acreage - Tonnage		
(b) Tame Hay	"	"
(c) Wild Hay	"	"
(d) Sorghum Hay	"	"
(e) All Hays	"	"
- 8 - Silage

(a) Percent farms reporting
(b) Acres per Farm
(c) Tons per farm
- 9 - Livestock - Percent Farms Reporting

(a) Cows - Number and Purpose
(1) Dairy
(2) Beef
(3) All Cattle (Over 3 mos.)
(b) Hogs (Over 4 mos.)
(c) Sheep (Over 6 mos.)
- 10 - Poultry - Percent Farms Reporting

(a) Chickens - Number and Purpose
(1) Laying Hens
(2) Broilers
(b) Number of chickens per farm
(c) Eggs produced per farm - dozens
- 11 - Dairy Products - Percent Farms Reporting

(a) Milk - Number of Cows - (quantity)
(b) Butter churned on farm
(c) Butter sold (pounds)
(d) Cream Sold (Pounds Butter Fat)
- 12 - Animals Slaughtered per Farm

(a) Percent of Farms Reporting
(b) Cattle and Calves per farm
(c) Hogs and Pigs
(d) Sheep and Lambs
- 13 - Vegetable Production for Home Use

(a) Percent of Farms Reporting
(b) Value per farm
- 14 - Irrigation

(a) Percent of Farms Reporting
(b) Acres Irrigated
(c) Wells Pumped
(d) Prime Mover Capacity
(e) Pump Capacity
(f) Average Lift

